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THE EMERGENCE OF SMART CITIES AND THE IMPORTANCE OF IOT FOR ITS DEVELOPMENT

A Study in Portugal: Lisbon

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I. ABSTRACT

The growing urbanization combined with the aging population and energy requirements lead cities to face serious challenges that can be mitigated with the development of Smart Cities, supported by Internet of Things applications.

With this Work Project, it was expected to define a strategy to improve Lisbon as a Smart City. Thus, after having analyzed the city's Current Positioning and conducted Primary Research, it was understood that traffic, inefficient management of solid waste and ineffective health services are the main problems. Adding to that, I found there to be a weak level of ideas and experience exchange between different cities in Portugal, a low level of citizen's engagement in smart projects and a lack of cooperation from universities. Therefore, the Smart Strategy Plan for Lisbon was developed taking these issues as the main priorities.

Keywords: *Urbanization*, *Smart Cities*, *Internet of Things*, *Improvement of Citizens' life*.

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1. INTRODUCTION AND OBJECTIVES

Cities around the world continuously face sustainability challenges associated to their different segments such as climate change, social inequalities, transportation, health or education (Newman and Jennings, 2008). Those challenges are mainly related with the increasing urbanization, motivated by the growing population in many cities, paired along with the shift to urban zones rather than rural ones (Falconer and Mitchell, 2012). In fact, more than half of the world's population now lives in cities (54%), and by 2050 this number will swell to about 66%, adding more than 2.5 billion people to the urban population (UNDP, 2014) (Appendix 1). The situation in Portugal follows the same trend. With a total population of 10,226,187 people, 65.9% live in urban areas (Appendix 2), Lisbon being the largest city with a population of 517,802 (Appendix 3), and it is predicted that this number will increase to 78.5% in 2050 (Appendix 4) (Worldmeters and Statista, 2019). Therefore, this situation can bring huge social, economic and environmental challenges that compromise citizens' quality of life, including: i) Inefficient Urban Infrastructures and Inadequate Public Services, since urbanization may lead to deficiencies that can come into economic (transport, utilities, telecommunications) or social forms (education, health, community services) (UNDP, 2017); ii) Environmental Degradation, given that urbanization causes irreparable deficiencies in natural resources and loss of biodiversity, motivated by the increasing use of land, contamination of natural resources, air pollution, and noise emissions (Etezadzadeh, 2015), and lastly, iii) Vulnerable Conditions of Living considering the effects of globalization that enhance manifestation of crime, violence and terrorism in cities, as well as the spread of precarious conditions motivated by higher unemployment rates and scarcity of affordable housing that may lead to suburbanization and the creation of new informal settlements (Beall and Fox, 2009). Because of these factors, urban planning should be aimed at building more effective cities, whose economies use resources efficiently to guarantee its viability (Falconer and Mitchell, 2012).

With this Work Project, the objective is to investigate the positioning of Lisbon in terms of smartness and how IoT has contributed to the development of the city as a Smart City, with the final goal of proposing an adjusted Smart Strategic Plan. To achieve that, government entities and citizens' perspectives have been studied, through semi in-depth interviews and quantitative surveys, respectively. Then, the insights from both sides were confronted and three scenarios were created in order to access i) the reasons that lead to the transformation, ii) the characteristics and goals associated to Smart Cities, iii) the level of engagement, iv) the importance attributed to different initiatives and projects, and v) the perception about risks, negatives consequences and barriers. Lastly, all of these insights led to the elaboration of seven main recommendations that should be developed to fulfill the Lisbon's Smart City Vision.

2. CONTEXTUAL BACKGROUND & LITERATURE REVIEW

To understand the emergence of Smart Cities, it is crucial to understand the reasons and motivations behind it, as well as its definition, characteristics, dimensions, risks and obstacles. These questions will be explored in the Contextual Background and further addressed for Portugal, and Lisbon more specifically. To complement this study, a Current Positioning analysis in terms of smartness will be done for the city.

2.1. Emergence of Smart Cities, supported by Internet of Things, as the Solution

The aforementioned concerns can be mitigated through the implementation of "*scalable, smart and innovative solutions*" that benefit from Information and Communications Technology (ICT) to create sustainable development, to stimulate economic competitiveness by improving productivity and lowering costs, which will ultimately enhance the quality of life.

Cities that take this approach are usually referred to as Smart Cities (SCs) (Falconer and Mitchell, 2012). Although this concept is not new, for years, its definition and even its end goal have remained vague. The term has been used to designate environmentally sustainable cities, with knowledgeable workers and dynamic economies, and infrastructures that work without any type of problem (McKinsey, 2018). However, the possibility of creating digitally connected

cities has recently acquired superior relevance. Nowadays, those concepts are converging, and SCs are being redefined as places where several actors employ applications of ICT and IoT in order to overcome urban challenges and promote a better quality of life for everyone (McKinsey, 2018). Firstly, IoT is considered as a key enabler, referring to the substantial use of innovative sensors and wireless communication between all types of physical objects with minimum human intervention, which creates a large volume of data (McKinsey, 2010). Thus, through the combination of technological interconnectivity and data collection, it is possible to benefit from more efficient transportation systems, more effective work, efficient resource utilization and the availability of more information to make knowledgeable decisions, that will ultimately result in the improvement of citizens' quality of life.

Nonetheless, Paskaleva (2011) defends that, in the current era, the cities performance is strongly influenced by the knowledge, education and social capacity of their citizens. Because of that, Boulos and Al-Shorbaji (2014) claim that the only way to develop healthier cities is by promoting the investment in technology, paired along with the development of the stakeholders (citizens, government entities and local businesses) involved in the process. However, Dustdar et al. (2017) believes that, although this process brings innumerous benefits for the citizens, they are not playing an active role in the progress of cities. Hence, two main challenges are their conversion into active ecosystem actors and the definition of how they will be integrated with the physical infrastructure (Bibri and Krogstie, 2017).

2.2. The Dark Side of the Solution

Despite the positive impact associated to Smart Cities being immense, it is crucial to be aware of the risks that may come with their development. One of them is the data management, given the high volume, velocity and variety of data, which makes its recognition (according to its importance) and analysis very difficult (Hammi et al., 2017). Because of that, it is very likely that disparity issues are registered, causing challenges such as data uncertainty and

trustworthiness. However, this is not the only issue associated with the large amount of data. Data over collection is another problem and it happens through "*apps that collect users' data more than its original function while within the permission scope*" (Hassanien, Shaalan, Gaber, 2017). Although it is required permission for every single app, the majority of the users accept it without the entire knowledge of what it really means for them. IoT makes this situation more complex since the members of a SC use diverse services and communicate with each other through multiple devices that are seamlessly connected using heterogeneous networks and systems, which are the target of hackers who want to invade their personal privacy, which leads to lack of security – translated into viruses, frauds and cyber-terrorism (Sicari et al., 2015).

Besides the risks presented, it is important to consider the existence of the following obstacles: i) Organizational – because of their singular territorial organization, some cities should be combined to make an integrated global vision and create a convergent development for everyone. In many cases, divergences occur between the supporters of the current SCs and the urban decision-makers, which may doubt its sustainability (Cohen and Obediente, 2014); ii) Legal - some public institutions could have pertinent and useful information, but it is not connected either shared with other public entities, because of legal impediments that avoid such compatibility of information exchange, restricting the way of how a Smart City should work (Cohen and Obediente, 2014) and iii) Citizen Participation & Involvement - governments aim to transform their cities with the help of technologies, but all these efforts go down if citizens are not aware of what a SC means and the benefits and opportunities they can bring (OECD, 2019). In fact, they must be able to recognize the main concern, strategies and goals for their cities and should act as actors at the middle of the implementation of smart projects.

2.3. The Dimensions of a Smart City

The designation of "smart" cannot be recognized holistically in a city. In fact, it is divided into many characteristics, which are singularly considered smart. Thus, Escobar and Henandez

(2015) define the concept as an urban entity that has an excellent performance in six disciplines: Smart People, Economy, Mobility, Environment, Living and Governance (Appendix 5).

The first dimension is i) Smart People and this is characterized by high level of Human Development Index (HDI), graduate enrolment ratio and qualification. Besides that, it is essential for a SC to have active and committed people, with a sense of belonging and community, a multicultural vision, high flexibility and resilience to the changing circumstances (Caragliu et al., 2011). Also, becoming a SC implies nurturing a competitive economy at urban level, being driven by innovation and supported by startups and universities, which lead to the growth of the entrepreneurial spirit of people in a society (Giffinger and Gudrun, 2010). This concerns to the ii) Smart Economy.

In addition, since SCs are focused on the mobility of people, and not only that of vehicles, other important dimension is iii) Smart Mobility. In a SC, urban and transport planning should be managed smoothly, in which the transport system is more efficient and environmentally friendly, offering affordable mobility services to ensure well-being in the city. It is measured through local and international accessibility, availability of ICT-infrastructure, sustainable, innovative and safe transport system (Albino, Berardi, Dangelico, 2015).

Likewise, the rising population requires a high use of natural resources in cities, which also brings environmental harms, and consequently, health disorders. Currently, cities are the principal polluters, but by becoming smart they can lower ecofootprints per inhabitant (Bonte, 2018). Thus, iv) Smart Environment is crucial as it promotes the protection of nature, valuing heritage and biodiversity. It stimulates an effective management system for the collection, treatment and removal of industrial wastewater, as well as a system to control disaster risk (Albino, Berardi, Dangelico, 2015).

The fifth dimension is v) Smart Living and it is characterized by the presence of diverse services in all kind of regions, educational facilities, tourist attractions and world class hospitals with

technology-enabled devices and equipment, good quality housing, as well as social cohesion (Gupta, Mustafa, and Kumar, 2017). For this component, the safety and security provided for women, children and senior citizens is crucial (Albino, Berardi, Dangelico, 2015).

Lastly, there is no SC without a Smart Governance, that is an innovative form of e-governance (Gupta, Mustafa, and Kumar, 2017). This brings new philosophies such as transparency, citizen and stakeholders' contribution in the assessment of government performance, improvement in government services, and operation through the use of intelligent technologies (Mohammad, Almarabeh and Ali 2009).

3. LISBON'S CURRENT POSITIONING IN TERMS OF SMARTNESS

In a general way and according to the Smart City Index 2019, Lisbon is positioned in the 76th place out of 102, Singapore, Zurich and Oslo being the top three of the ranking. From a list of 15 indicators, survey respondents identified affordable housing, road congestion, corruption, public transportation and unemployment as the five main problems in Lisbon (Appendix 6).

Furthermore, to analyze Lisbon Positioning each one of the above-mentioned dimensions will be studied. This analysis will be supported by several indicators, representing the country's situation, and further presentation of the initiatives developed. All the dimensions are interlinked so that each project may contribute to several ones, simultaneously.

Starting with the Smart People dimension, Portugal's HDI value for 2017 was 0.847, positioning it at 41 out of 189 countries and the city's GNI per capita increased by about 35.8%, between 1990 and 2017 (UNDP, 2018). On the other hand, the number of students enrolled in universities has decreased from 383.627 to 372.753, in the period 2010-2018 (Pordata, 2019).

Since the promotion of committed actors is crucial, Lisbon is working to promote a more active citizen engagement, with platforms such as *Lisboa Participa,* that allows the digital interaction between Government and citizens and that promotes the participatory democracy. Additionally, *Lisbon Portal Open* makes the data available to the citizens to potentiate its reuse and the creation of new services that add value to the available contents. Besides that, the availability

of *WiFi network in all markets* should also be highlighted. It is already implemented in Mercados da Ribeira and Campo de Ourique, so that visitants can have free access to internet and to informative contents that maximize their experience (Lisboa Inteligente Website).

Secondly, and analyzing Smart Economy, it is possible to realize that, although the productivity level has increased from 1995 to 2018 (a ratio from €10.6 to €21.9), it is below the average of the EU28 that registered an evolution from €20.8 to €40.6 (Pordata, 2019). On the other hand, according to a study made by the Digital Transformation Monitor, over the last five years, Lisbon has been promoting an entrepreneurial vision, aiming to build local networks and encouraging citizens, businesses, universities and organizations to create new projects (EC, 2017). *Lisbon Robotics Cluster* and *Smart Open Lisbon* are initiatives in process of implementation, which promote investment in R&D, and transference of technology through the collaboration with universities, around problems for the region. Contrarily, *LxDataLab* is currently in conception, and it intends to develop a new generation of public services in SCs, exploring advanced analytical tools, artificial intelligence and super computation to analyze complex combinations of data in areas of public interest (Lisboa Inteligente Website).

Smart Mobility is particularly important for Lisbon considering the number of motorized vehicles, per thousand of inhabitants, that increased from 584.7‰ to 625.5‰ (per year) and the number of passengers using the Portuguese subway that increased from 236.328 to 244.137 (thousand), in the period 2010-2018 (per year) (Pordata, 2019). Lisbon is already investing in several initiatives, *Gira. Bicicletas de Lisboa* (Lisbon bikes) being the most popular one, which aims the transformation of Lisbon in a more accessible, less polluted and less stressed city upon the installation of an app. Another trendy initiative is *App Carris*, which allows the passengers to know how much time is left to the bus arrival to a certain bus stop and that creates alerts for the most used and favorite buses. Additionally, *Sensorização do Eixo Central* (Sensorization of the Eixo Central) promotes the knowledge in real-time about the availability of free spots in

Eixo Central de Lisboa and *C-Roads* allows the prioritization of buses and heavy emergency vehicles in road intersections (Lisboa Inteligente Website).

The development of a Smarter Environment comes from the need to reduce the gas emissions, per inhabitant, in Portugal, that in the period 2013-2017 increased from 4.7 ton/ to 5.4, as well as the electricity consumption, per consumer, that in the same period, increased from 7 259.1 kilowatt/hour to 7 365.0 kilowatt/hour (Pordata, 2019). To invert this situation, *Sharing Cities: Street Lighting* is being promoted, and they not only reduce energy consumption, but also increase safety. Thus, streetlights could, for example, become brighter when movement is perceived, so that it becomes clear from a distance that traffic is upcoming or indicating when an emergency vehicle is driving, which could save time and, consequently, save lives (Dubbeldeman and Ward, 2015). Also, *ALFA-AMA Smart Sustainable District* focuses on sustainable integrated solutions regarding climate change, carbon emissions and innovation. Regarding waste management, the urban waste selectively collected has increased from 14.8% to 18.6% between 2010 and 2017 (Pordata, 2019). Thus, an efficient waste management is mandatory, and because of that, *Sensorização de Depósitos Coletivos de Resíduos* (Sensorization of the Collective Waste Deposits) has been developed, allowing the detection of the waste volume in the container (avoiding unfilled or overfilling containers), which optimizes the collector truck routes and the reduction of waste collection costs up to 20%, as well as the maintenance of cleanness of waste collection sites.

Looking at the Living component, it is important to highlight the aging population, in Portugal. In fact, the country's aging index has increased from 102.2% in 2001 to 127.8% in 2011 and the elderly dependency index has increased from 24.2% to 28.8%, in the same period (Pordata, 2018). Under these circumstances, *Projeto Radar* and *Teleassistance* are two initiatives promoted in Lisbon to support the most vulnerable ones and, in this way, stimulate Smart Living (Lisboa Inteligente Website). The first one wants to promote the recognition, evaluation and

monitoring of old people, through georeferentiation and centralization of all the information about people older than 65 years, in a technological platform, being possible to manage efficient answers in collaboration with the community and institutions. The second project is directed to the same target of people and to the ones that were diagnosed with deficiencies or incapacities in a level equal or superior to 60%. This is based on the free installation of smart electric devices with direct and easy link to a fixed-line at the beneficiaries' homes, with the ability to make a direct connection to the Sala de Operações Conjuntas or the Firefighters.

Lastly, addressing Smart Governance to Portugal, a study made by EC found that the country is at the top of best performing European countries in terms of providing public services over the internet and adapted to mobile devices. Examples of that are *Na Minha Rua Lx* - an application that allows the participation and monitoring of occurrences in public spaces (e.g., urban hygiene, sanitation, safety or street lighting) and *Centro Operacional Integrado Lisboa* that ensures the city's intelligent management, where the responsible people for each service can work in an integrated, preventive and cooperative way, from a room that is monitored in real-time and supported with technologies of information (Lisboa Inteligente Website).

Besides the presented initiatives, there is also the integration in several projects that have contributed to Lisbon being awarded with the *European Green Capital Award 2020*. This has resulted from the development of the *Programa Operacional Regional de Lisboa 2020*, with the purpose of developing an innovative large-scale ecosystem, focused on increasing its population (by promoting housing and adopting smart initiatives related to ageing), creating more jobs (by developing its human capital) and stimulating a better city. Besides that, in 2015, Lisbon was the first city to integrate the *Covenant for Climate and Energy*, by adopting a combined approach to emission reduction and adaptation to climate change. Lastly, the capital is also encouraging the transition to renewable energies, including solar power, for instance by amending the town planning codes (Brussels Smart City, 2018).

4. ADDRESSING THE WORK PROJECT OBJECTIVES

According to Paskaleva (2011), Boulos and Al-Shorbaji (2014), the performance of Smart Cities is not only linked with technology but also with the development of the cities' stakeholders. Thus, after having conducted the literature review and examined the Lisbon's Current Positioning, the perception of Citizens and Government Entities were evaluated, to suitably address the Work Project's challenge – *How can Lisbon be a Smarter City?*

4.1. Work Methodology

The objective of this research was to explore the positioning of Lisbon as a SC, and how it would be enhanced. To achieve that, Primary Research was conducted, directed to the Citizens and Government (Tables 1 and 2, respectively) with the ambition to address the Research Sub-Question - *What is the perspective of each group about SCs and about Lisbon as one of them?*

Firstly, through a qualitative research design, two in-depth semi-structured interviews were conducted (Appendix 4) to three professionals in the area of Smart Cities in Lisbon: João Tremoceiro (Lisbon Urban Management and Intelligence Center Director), Vasco Móra (Advisor of Lisbon's Mobility Deputy Mayor) and David Cunha (Senior Adviser in the Mobility and Urban Intelligence Deputy Mayor's Office). On average, each interview lasted between 45 minutes and 1 hour and they were performed face to face. Although the interview guides have been based on literature review topics and shared with them before, the questions remained open in order to explore new ideas and to be able to find out other relevant subjects. This research method was useful for gathering specialized and reliable insights from experts who have deep knowledge about this subject and that have been following the whole evolutionary process. Thus, they were questioned about the main problems of a city, the required characteristics for a SC having such designation, main barriers and challenges during the transformation, the role of partnerships, and the initiatives implemented and their impact.

Once a more specialized perspective was known, a survey (Appendix 5) with a sample of 74 respondents (N=74) was conducted to understand the citizens' level of knowledge about Smart

Cities in general, and Lisbon in particularly (with 49 from Lisbon and 25 from other cities), as well as what they would most value in a SC. To ensure the most varied set of answers, the inquired people had different genders, age levels, educational qualifications and were from different cities. Since the city in study was Lisbon, all the questions were in Portuguese so that the language was not a limitation. Besides that, although there were not pre-recruitment questions, the inquiry was based on conditional questions, so that even the people who were not familiar with the concept were considered for the survey, since the objective of a Smart City is to be completely inclusive. Because of that, the opinion of that group of people should also be considered in order to understand the needs and priorities of different segments of people and to improve everyone's life. In this way, the interviewees answered about the important characteristics of a SC, the recognition of problems, as well as the upcoming risks, negative consequences and general impact for the quality of life with its development. Besides that, citizens were inquired about their engagement for this transformation and their practices, more concretely. To understand which initiatives citizens most valued, they were asked about the ones they knew (all of them already implemented) and the evaluation of new initiatives, according to their needs and preferences. The combination of all of this was crucial to make different scenarios and to provide well-reasoned recommendations.

4.2. Primary Research Insights from In-depth Semi-structured Interviews to Government Entities and Quantitative Surveys on Citizens

Table 1 – Primary Research Insights

RESEARCH SUB-QUESTION 1: What is the Government's Perspective?	
With slightly different answers regarding the required characteristics for a SC, the interviewed people agreed that the main goal is to promote the improvement of life in an inclusive way, by adapting the existing services and creating more innovative ones.	
Topics Covered	**Main Findings & Interviews' Quotes**
A. Importance of the Transformation	This transformation comes from the necessity to solve two main problems: the carbonization and lack of personalization. Thus, it is defended that it is a

(i.e. how necessary and urgent the transformation is and what kind of problems it would solve)	matter of survival, required by the citizens. Even though there are citizens who are not available to participate in this process for being less receptive to innovation and being afraid of the unknown, everyone will see their quality of life improved through the promotion of inclusive services and adjusted to the specific needs of each group. Also, the citizens' perspective about this process varies accordingly to the citizen's age: younger people are more receptive to having more innovation and disruptive means, while the older ones want better quality in the conventional services.
▪ *"The transformation is inevitable, being the citizens the center of the necessity, and the survival of cities will depend on how smart the cities will be."* ▪ *"What lacks is the identification of citizens profiles so that it is possible to create tailored solutions."*	
B. Required Characteristics and Goals (i.e. what defines a Smart City and what is its main vision)	Regarding this topic, two different definitions were gathered. One of them is broader and considers that a SC is one that has the capacity to predict what will happen so that the city can act proactively, instead of just being reactive, through an efficient data analysis. Its final goal is to provide better services, to improve citizens' life, and consequently, the economy in general. Because of that, the creation of innovative projects does not make sense if they will not result in real benefits for everyone. In contrast, the other definition is more specific in their criteria and it should imply the use of ICT to improve the quality of life by increasing sustainability (namely the transparency, participation, efficiency and reduction in the resources' consumption). Lastly, it is pointed out that the SC designation is not a title that can be acquired, but a process that is completed over time.
▪ *"The capacity to measure is critical to be able to anticipate. To achieve that, a city should have a brilliant capacity to treat the data in an efficient way since this by itself is useless."* ▪ *"There are more than 300 definitions, but a SC implies the using of ICT to facilitate all the characteristics that will ultimately promote the improvement of quality of life."*	
C. Main Barriers and obstacles (i.e. the potential existence of organizational, legal and citizens' obstacles)	The biggest challenges identified were i) collaboration between different types of organizations, since the public companies do not give access to information (e.g., traffic flows), ii) implementation of the legal frame since Lisbon is an old city, being difficult to incorporate certain infrastructures, iii) lack of identification of citizen's profiles to create more personalized solutions, iv) insufficient cooperation between universities and private SMEs, as well as reluctance to apply innovative business models and v)

	regulatory difficulties for start-ups that are often discouraged by tough procedures and lack of information.
▪ *"If companies collaborate amongst them it would be created an ecosystem of innovation."*	
D. Role of Partnerships (i.e. which types of partnerships exist and how they can contribute to the success of a Smart City)	Partnerships are divided into three types: public entities, academic (civil engineering labs, research institutes) and corporate. Besides that, all the interviewed people mentioned the importance of start-ups given their openness to new ideas, their power to invest small amounts of money in a fast way and the possibility of developing "*proofs of concept",* which allows a certain solution to be improved, but always taking into account the cost-efficiency ratio of each solution. On the other hand, the Intelligence Center Director believes that although startups may have interesting ideas, it is not possible to scale them, neither participate in most of the public tenders given its lack of financial capacity.
▪ *"Partnerships with universities mean reciprocal relations: the city gives the resources to students, while they have the opportunity to create something new."* ▪ *"Some of the start-ups try to replicate the projects in a bigger scale but then they start having other kind of problems."*	
E. Social disparities (i.e. between different cities in the same country and the consequences of that)	For the Intelligence Center Director this is not an issue, because if the development of a SC is done correctly, there are only positive consequences. However, the Advisor of Lisbon's Mobility Deputy Mayor considers that it is difficult to keep up different cities with the same level of development and inclusivity since each one has different laws, politics and priorities. For example, Lisbon has invested more in micro-mobility (electric scooters), while Porto has essentially invested in digital mobility. Nonetheless, it provides the opportunity to learn ones with others and to create synergies on a country level. Yet, this information crossing is not actually being potentialized.
▪ *"If the development is according to the true definition, nothing wrong will happen"* ▪ *"Although we try to have direct contact, there are different politics between the cities."*	

Source: Author, based on Primary Research Insights from the Interviews

Table 2 – Primary Research Insights

RESEARCH SUB-QUESTION 2: What is the Citizen's Perspective?	
Through the survey's analysis, it was concluded that the majority of people are aware of what a SC is but less than 50% believe to be engaged in this transformation. Besides that, the most popular initiatives are the ones related to the Smart Mobility dimension.	
Topics Covered	**Main Findings & Surveys' Quotes**
A. Main problems & Impact of transformation (i.e. from a list of ten main problems, which are the ones that would be easier to be solved with SCs)	For the inquired people, SCs would be valuable to solve traffic (75.7%), inefficient health services (67.6%), management of solid waste (52.7%), air pollution (50%) and public safety (41.9%). Contrarily, lack of accommodation, water contamination and social exclusion showed the lowest and the same percentage (25.7%) With the development of SCs, around 90% of people believe to see their life improved at a level equal or above 5 out of 10. From the ones that ranked it in inferior levels, more than 50% were unfamiliar with the concept, which have might led to this opinion. Lastly, it was not found any visible relationship between the age and the level of understanding.
B. Concept awareness & its characteristics (i.e. SC's level of understanding)	The majority of people (62.2%) affirms to know what a SC is, associating the utilization of technologies (84.8%), sustainability (78.3%) and the presence of ICT (73.9%) to this. On the other hand, from people who have answered to know the concept, just 4.3% associates this to participative politics and 17.4% to personalized services.
C. Awareness of the risks (i.e. recognition of risks and which ones)	Around 26% of the inquired people do not believe in the existence of risks or negative consequences with the development of SCs. However, the ones that have the opposite opinion, highlighted privacy issues (65.5%), increasing social disparities between different cities in the same country (54.5%) and lack of knowledge (52.7%) as the main problems.
D. Level of engagement and role for the promotion of the concept (i.e. evaluate how people are dealing with the SCs' development in	Less than half of the sample (43.2%, 34 people) considers to be engaged and promoting the concept. However, in reality, when confronted with the question about the concrete way that they were promoting the concept, just 20 people answered and three of them said that, in fact, were doing nothing ("*At the moment, I am not doing anything*", "*I have not done anything but I support the idea*"). Besides that, it was interesting to observe that nine citizens that had affirmed not to know the concept stated to promote it. Nonetheless, after a deeper analysis, it was found that only two of that group answered with concrete answers. Amongst the ones that answered "Yes" and that are

terms of acceptation and promotion)	effectively doing it, they are promoting communication by spreading information, sharing opinions and looking for new details, using devices and mobile applications where the intelligence is implemented, promoting sustainability's practices, taking advantage of free WiFi and help in the development of 5G. Lastly, it was not found any visible relationship between the age and the level of engagement.
▪ *"I support Smart Cities and try to know more about this"* ▪ *"I try to give my contribution through participative politics that could promote the intersection of technology adapted to sustainability and to the improvement of conditions of life such as the implementation of walkways with floor warning lights"* ▪ *"Using technologies where the intelligence is implemented and being receptive to new ones"* ▪ *"Promoting sustainability"/ "Recycling" / "Trying to walk more and choose public transportation instead of using the car"/ Car sharing"* ▪ *"I download apps that facilitate my quotidian life"* ▪ *"Contactless in the multibank card"* ▪ *"Helping in the development of 5G"* ▪ *"Using Free Wi-Fi"*	
E. The most popular initiatives (i.e. which are the initiatives that citizens recognized)	*WiFi in the markets* (56.8%) (Smart Citizens), *Gira. Bicicletas de Lisboa* (Lisbon bikes) (68.9%) and *App Carris* (56.8%) (Smart Mobility) were the most popular ones, contrarily to *Rede LoRa* (LoRa Networking) (1.4%), *C-Roads* (1.4%) and *Centro Operacional de Lisboa* (Lisbon Operational Center) (2.7%). Also, it was registered one person that, besides to know all of the presented initiatives, also showed a proactive attitude in SC's development (being involved in the development of 5G).
F. Importance of applications (i.e. ranking of applications in all the different areas)	The applications that people most value are related with i) Smart Mobility (Systems of Intelligent and Connected Transport), ii) Smart Environment (Smart Lighting, Smart Management of Solid Waste, Monitorization of Air and Water Quality) and iii) Smart People (Smart Schools). On the other hand, applications such as Autonomous Vehicles, Telemedicine, Smart Meters and Bike-sharing are the ones with the least receptiveness.

Source: Author, based on Primary Research Insights from the Surveys

4.3. Analysis and Confrontation of Results between both parts

Table 3 – Primary Research Insights

CONFRONTATION OF BOTH SIDE PERSPECTIVES			
This study is divided into five themes and each one of them will be studied according to three scenarios, built based on the previous two analysis. As already seen, there are not only differences inter groups (Government and Citizens) but also intra groups, considering their different ages, levels of understanding, priorities and perceptions.			
	SCENARIO 1	**SCENARIO 2**	**SCENARIO 3**
A. Why to change?	This is required by the citizens	To solve three problems	To grow sustainably
	Mainly the ones who are more informed, by recognizing the current problems and the effectiveness of a SC to solve them.	Namely, traffic (and pollution associated to that), inefficient health services, and management of solid waste.	Living in an era of resource scarcity, increasing efficiency to guarantee cities' viability is mandatory.
B. What does the concept of Smart City mean?	This designation is acquired over an evolving process	Capacity to treat the data efficiently	Transparency and participative politics
	Since a SC is constantly evolving and the citizens' needs always changing, this is a process to be completed.	With the goal of predicting future events and, based on that, improve citizens' life.	So that there can be a complementarity of benefits for both parts – Government and Citizens.
C. How is the level of engagement characterized?	According to the age	According to the level of awareness	According to the organization
	Contrarily to the insights gathered in the interviews, the survey did not prove that younger people were more engaged in SC's development.	As observed with age, higher levels of awareness did not seem to be related with higher level of engagement.	Low level of partnerships with universities, contrarily to start-ups that give a huge contribution in terms of innovative ideas.
D. Which applications and initiatives	Smart Mobility	Smart Environment	Smart People
	This is the dimension whose initiatives are the	Citizens ranked the applications related with	*WiFi in the markets* and Smart Schools are

are the most relevant ones?	most popular and valued ones.	the air, water and waste monitoring as a priority.	considered as very relevant for citizens.
E. How is the perception about barriers, negative consequences and risks?	Inexistence of negative consequences	Lack of cooperation	Privacy issues, social disparities, lack of knowledge
	If a SC is developed correctly, there are no negative consequences since it should only promote inclusivity and quality of life.	From public companies (that do not give access to all of their information), universities, citizens and SMEs.	These were the main risks identified in the Primary Research, according to this order of relevance.

Source: Author, based on Primary Research Insights

4.4. Discussion

By crossing the insights from the Primary Research with the country's current situation, it was possible to understand the main needs and priorities, for different entities, for each dimension. Firstly, although Portugal has a high HDI, citizens show low levels of engagement regarding IoT initiatives, crucial to develop SCs projects, which corroborates the Dustdar's perspective and highlights the challenge initially stated to covert the citizens into active actors.

Besides that, it was recognized a weak level of ideas exchange between different cities, as well as lack of cooperation between universities and some public companies. Adding to those problems, others were also recognized, such as traffic (with consequently pollution issues), ineffective management of solid waste and inefficient health services. As seen in the Lisbon's Current Positioning, there are already initiatives that aim to combat the first two ones, such as *Gira. Bicicletas de Lisboa* and *Sensorização do Eixo Central* (for reducing congestion) and the *Sensorização de Depósitos Coletivos de Resíduos* (for waste management). However, since the designation of a SC is "*not acquired as a title but this is a process to be completed*" (Deputy Mayor's Office perspective), these dimensions require improvements that will be discussed.

Additionally, although several e-government initiatives are in development, only 4.3% of the inquired citizens associate the SC concept with participative politics, which may indicate that

these initiatives are not being communicated appropriately or that this dimension needs, in fact, to be reinforced. On the other hand, no pertinent smart initiatives for health services were identified. Thus, for further recommendations, it is important to take into account the aging Portuguese population and that citizens do not consider telemedicine as relevant.

Lastly, Smart Environment is a general concern for all the intervenient people in this study, so that the promotion of resources optimization should be a priority and the aggregation between energy production and its consumption can be the beginning of its revolution.

It is not possible to finish this analysis without looking at the apparent contradiction between the citizens' perspective and the main goal of a SC. On one hand, social exclusion was not considered as a problem that would be easily solved with the development of a SC and, at the same time, 65.5% of the inquired people consider the "increasing social disparities between cities in the same country" as one of the main risks that would come from that. On the other hand, a SC's central goal is to promote everyone's inclusivity.

5. RECOMMENDATIONS

The development of Lisbon Smart City Strategy sits across Council's other plans and is intended to be implemented by Council business units, supported by a multidisciplinary Smart Project Team. This represents a call-to-action to business, government and the community to work together to build a SC. It is designed to be flexible since new opportunities and partnership options continually arise as digital technologies evolve.

Hence, to fulfill the Lisbon's Smart City Vision that will be defined as *"In the future, Lisbon aims to be amongst the 40 most developed Smart Cities and to mitigate the concerns identified in the Research Analysis"*, a roadmap of specific projects and initiatives is needed. Thus, seven main recommendations will be presented, and they should be paired along with a Plan of Sensibilization and Communication. This could be done through the promotion of Smart Summit Events, financed by the Government (partially or totally), to enable a better

understanding of the current initiatives and the promotion of the ones that will be suggested in the following recommendations. Besides that, it would stimulate networking situations and exchange of ideas between different stakeholders, encouraging a collaborative environment.

Table 4 – Recommendations for the six dimensions

1. Smart People: Development of a Smart School Program
WHY? Three crucial factors led us to the first recommendation: i) Smart Schools were found as one of the main priorities for citizens, ii) it was recognized insufficient cooperation with universities in innovative projects and iii) low level of citizen's engagement regarding IoT.
HOW? This program would enable the i) digitization of education with a combination of online education with on-campus education, ii) adjusted learning and advising, by providing the opportunity to students to analyze valuable data and to create insight in their personal profile, iii) personalization of education, with the possibility to combine education services from different education entities and iv) the possibility for corporate universities to define the education program, according to the innovation needs and promoting a favorable relationship with students from the beginning (Dubbeldeman and Ward, 2015). This, besides increasing the educational service satisfaction and allow people to adjust to the fast changes in society, also stimulates next generations to be more engaged in their communities and in their cities. Lastly, it promotes everyone's inclusivity with the possibility of making it available everywhere, including distant or rural zones, where commuting to schools may be more difficult.
2. Smart Economy: City Platform Protocol
WHY? It was highlighted the importance of sharing ideas and experiences between different cities to create synergies, stimulate the economy and competitiveness at the country level. To answer this need, the creation of a platform – City Platform – is suggested.
HOW? It would allow the communication and operations development across communities, promoting an ecosystem of solution improvement and stimulating innovation. It would aim to work across diverse cities by interconnecting them, and ultimately, creating the "Internet of Cities". With this, on one side, innovators take advantage of a solid market for their solutions, and on the other one, cities enjoy solution choice, reduced costs and risks, as well as increased collaboration and learning, which finally promotes the competitiveness at a global scale (Amsterdam City Projects).
3. Smart Mobility: Acceleration of Bike Commuting and Promotion of Carsharing
3.1. Acceleration of Bike Commuting
WHY? Although bike-sharing was one of the applications with the lowest citizen's receptiveness, it may be associated to perceived and actual safety issues, deficiency of bike lanes and infrastructures, lack of daylight, and inconvenience. However, *Gira. Bicicletas the Lisboa (EMEL)* was the most known initiative between citizens and cycling is, in fact, among the most common forms of smart and

sustainable transport (Haixiao, 2012). Besides that, it also gives an important contribution for lowering traffic congestion – a trend in Lisbon, identified by citizens as the main current problem, as well as the reduction of gas emissions and the improvement of air quality.
HOW? This can be promoted by the installation of micro-radar to count passing cyclist on its transportation itineraries to improve its transportation organization (Jeff McMahon, 2013); installation of LED lights in the roadway to alert cyclists to keep their velocity so that it is easier to catch green lights at upcoming intersections and the installation of sensors to identify groups of cyclists riding together and make intersection lights greener and longer. Another way is by using big data to encourage bike commuting. There are already apps that allow bikers to upload GPS data about their bike rides to a main portal, where it is possible to compare their distances and velocities with other cyclists. In a near future, personal mobility data will be stored into a central database in order to track citywide developments in fitness, commuting efficacy and trail conditions.
3.2. Promotion of Carsharing
WHY? As already said, the main problem identified by citizens was the traffic in Lisbon, with drastic conditions for the environment. Another solution is the promotion of carsharing programs, that besides reducing the congestion in Lisbon, also allow consumers to benefit from automobile ownership without the resultant high fixed costs (including acquisition, insurance, maintenance, and parking costs) (Viechnicki et al., 2015).
HOW? This would be developed in two ways. The first one would be by building awareness of carsharing as a cheaper alternative to car ownership. It would be possible with the collaboration of transportation agencies that could encourage this option as part of a strategy to generate superior public consciousness of multi-modal opportunities and the idea that "*living without a car is not only possible, but even preferable*" (Bell, 2012). The other way is by providing public parking spaces for carshare vehicles since the rates carsharing providers pay for parking range from free (as specific spaces included in partnerships) to the normal market prices. To encourage this, Lisbon could opt to discount the price for public parking or even to provide spaces for free. Additionally, other cities have realized that providing public parking spaces for carshare vehicles, for free, brings a better ROI than other investments such as the expansion in the roadway infrastructure.
4. Smart Environment: Sharing Renewable Energy between Households
WHY? This is crucial for citizens since they are already feeling the impacts of climate breakdown. Because of that, the Government has encouraged the transformation towards a fossil-free energy system as part of its Strategic Smart Plan.
HOW? By coordinating energy supply and demand between houses, neighborhoods can become energy neutral and share their resources according to the different households' needs at each moment (Amsterdam Smart City Projects). This is only possible through the implementation of powerful batteries that can store wind and solar energy for use when the sun is not shining, or wind is not

blowing. Thus, households are consumers and producers, at the same time, while the communities are increasingly connected (promoting Smart Living).
5. Smart Living: Assistance to Senior People to overcome age-specific barriers
WHY? Senior people were found to be at the top of priorities considering the Portuguese aging population. *Projeto Radar* and *Teleassistance* are already two of the initiatives implemented oriented for senior people that were detected to be in isolation situations. However, there is also the need to help them overcoming age-specific limitations, such as mobility, visual and hearing deficiencies and high illness vulnerability, particularly chronic ones. Thus, this initiative aims to combine Smart Homes and Smart Cities, with the support of ICT infrastructures, to improve Smart Living for this group of citizens.
HOW? This would be focused on visual and hearing problems. ICT would help to overcome the first by providing supported city apps adjusted to blind users, audible and vibrotactile signals which tell people their location and accessible shopping for visually impaired citizens, supported by mobile technologies. For the second problem, it is suggested the adoption of devices that can monitor the elderly in their quotidian responsibilities, rehabilitation systems and video games to boost cognitive capacities, and a method that translates voice to text or which converts and reproduces sign language (Skouby, 2014).
6. Smart Governance: Democratization by Crowdfunding
WHY? Although Portugal is considered as one of the "best performing European countries in terms of providing public services over the internet and adapted to mobile devices", a small percentage of the inquired people associate the concept with participative politics. In this way, smarter and more inclusive way of financing public projects is suggested.
HOW? By adopting this, citizens and companies can decide for themselves how relevant they consider the initiatives, promoting the democratization of investment decisions and boosting citizen engagement. Thus, it provides opportunities for new groups that may have a mutual interest to invest in Lisbon or its neighborhood. In return, the city can offer them a discount on the city taxes, donations, community shares and municipal bonds (Dubbeldeman and Ward, 2015). Although this model may not be suitable for all SC initiatives, civic crowdfunding offers special potential for small-scale and limited-time projects with a social purpose.

Source: Author, based on Literature Review and Primary Research Insights

6. LIMITATIONS AND FUTURE LINES OF RESEARCH

Despite the contributions made by this study, there are certain limitations. Firstly, no detailed data for each dimension was encountered for Lisbon that would allow to measure the city's evolution in terms of smartness and the comparison with other countries. Besides that, and

concerning the sample, the interviews to professional people, although representative of different areas, may not cover all the pertinent insights. Thus, it does not allow to draw generalizable inferences from the results. Additionally, even while the sample studied was N>50, which represents a satisfactory benchmark (Vigoda-Gator, 2008), it would be more diverse considering the existence of few respondents in the level ">45 years old" and the inexistence of people "<18 years old" as well as with "Basic School" education. Nonetheless, given time constraints, it was not possible to gather more answers for the quantitative survey neither the qualitative interviews. Furthermore, the questions to rank according to the level of importance may not be accurate since the interpretation of the scale may not be faced in the same way for everyone.

Taking these limitations into account, future research projects would benefit from a larger number of entities from the Government and a larger sample of citizens, with a more diversified education level and age as well as the extension of the research sub-questions to other game-changing factors. Furthermore, valuable lessons may arise from people who are working at start-ups and SMEs, given their importance in terms of partnerships. In the future, this work project would be the basis for other cities in Portugal and it would be interesting to understand the impact on the city's level of smartness, with the implementation of the suggested recommendations, as well as how the citizens' level of understanding has changed.

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THE EMERGENCE OF SMART CITIES AND THE IMPORTANCE OF IOT FOR ITS DEVELOPMENT

A Study in Portugal: Lisbon

APPENDICES

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A Project carried out under the supervision of:

Professor Luís Manuel da Silva Rodrigues

03-01-2020

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1. TERMINOLOGY

Crowdfunding: process of funding a project or venture by collecting small amounts of money from a large number of individuals, usually via Internet.

Human Development Index: geometric mean of standardized indices for each of three categories – "*long and healthy life, being knowledgeable and have a decent standard of living*" - and it is used to rank countries' levels of social and economic development.

Information and Communication Technology: broader term for Information Technology and corresponds to a varied set of technological tools and resources used to transmit, collect, produce, spread or exchange information. This includes computers, websites, emails, live broadcasting technologies, radio, television, fixed or mobile, satellite and videoconferencing.

LoRa: its devices offer attractive features for IoT applications including long-range, low power consumption, and safe and protected transmission. It can be used to solve challenges such as energy management, natural resources saving, pollution monitoring and infrastructure efficiency.

Smart City: use of smart computing technologies to make the critical infrastructure dimensions and services of a city (people, economy, mobility, environment, living and governance) more intelligent, interconnected and efficient (Harmon, Castro-Leon, 2015).

Smart-Up: aggregation of the concepts "Smart City" with "Start-Up".

Smart Vehicles: they are linked to safety issues by an appropriate combination of functionalities such as control, communication and computing technologies, which allows to assist drivers to take their decisions, preventing wrong driver's behaviors.

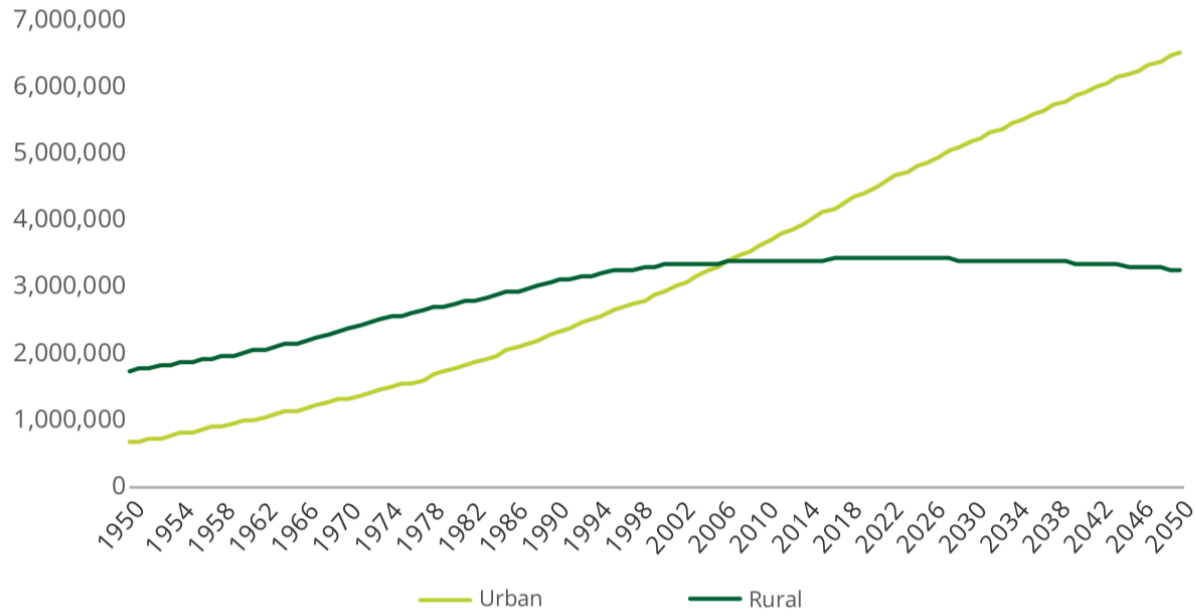
5G: advanced wireless technology that allows much faster data download and upload velocity, wider coverage and more steady connection.

2. LIST OF ABBREVIATIONS AND ACRONYMS

EC	European Commission
HDI	Human Development Index
ICT	Information and Communication Technology
IoT	Internet of Things
IT	Information Technology
OECD	Organization for Economic and Co-operation Development
SC	Smart City
UNDP	United Nations Development Program

3. LIST OF FIGURES

Appendix 1 – Urban and Rural Population of the world, 1950-2050 (in thousands)



Source: United Nations Department of Economics and Social Affairs, Population Division, World Urbanization Prospects (2014 revision)

Appendix 2 – Population of Portugal (2019 and historical)

Year	Population	Yearly % Change	Yearly Change	Migrants (net)	Median Age	Fertility Rate	Density (P/Km²)	Urban Pop %	Urban Population	Country's Share of World Pop	World Population	Portugal Global Rank
2019	**10,226,187**	-0.29 %	-30,006	-6,000	44.3	1.28	112	65.9 %	6,743,854	0.13 %	7,713,468,100	48
2018	**10,256,193**	-0.31 %	-32,334	-6,000	44.3	1.28	112	65.4 %	6,710,993	0.13 %	7,631,091,040	48
2017	**10,288,527**	-0.36 %	-37,011	-6,000	44.3	1.28	112	64.9 %	6,678,201	0.14 %	7,547,858,925	48
2016	**10,325,538**	-0.41 %	-42,813	-6,000	44.3	1.28	113	64.4 %	6,646,760	0.14 %	7,464,022,049	47
2015	**10,368,351**	-0.43 %	-45,541	-28,000	43.9	1.28	113	63.8 %	6,617,197	0.14 %	7,379,797,139	46
2010	**10,596,058**	0.17 %	17,513	18,427	41.6	1.37	116	60.9 %	6,451,825	0.15 %	6,956,823,603	43
2005	**10,508,495**	0.41 %	42,277	35,671	39.4	1.45	115	57.8 %	6,077,668	0.16 %	6,541,907,027	43
2000	**10,297,112**	0.40 %	41,157	34,721	37.8	1.46	112	54.7 %	5,633,127	0.17 %	6,143,493,823	42
1995	**10,091,325**	0.39 %	39,192	29,824	36.0	1.48	110	51.4 %	5,187,432	0.18 %	5,744,212,979	45
1990	**9,895,364**	-0.07 %	-6,764	-29,575	34.2	1.62	108	48.2 %	4,769,183	0.19 %	5,327,231,061	45

Source: Statista (2019)

Appendix 3 – Number of people in Portuguese Cities

Name of the City	Population
Lisbon	517802
Porto	249633
Amadora	178858
Braga	121394
Setubal	117110
Coimbra	106582
Queluz	103399
Funchal	100847
Cacem	93982
Vila Nova de Gaia	70811
Algueirao	66250
Loures	66231
Felgueiras	58065
Evora	55620
Rio de Mouro	54695
Odivelas	54624
Aveiro	54162
Amora	52577
Corroios	52520
Barreiro	51280
Monsanto	50000
Rio Tinto	49966
Sao Domingos de Rana	46718

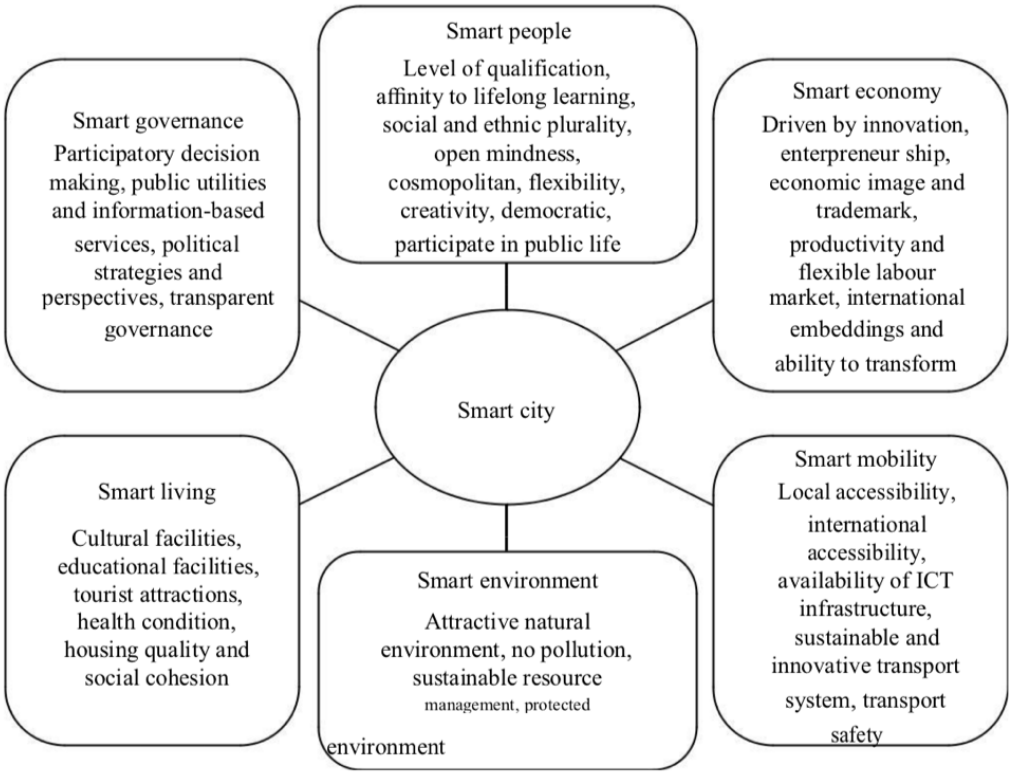
Source: Worldometers (2019)

Appendix 4 – Portugal Population Forecast

Year	Population	Yearly % Change	Yearly Change	Migrants (net)	Median Age	Fertility Rate	Density (P/Km²)	Urban Pop %	Urban Population	Country's Share of World Pop	World Population	Portugal Global Rank
2020	**10,196,709**	-0.33 %	-34,328	-6,000	46.2	1.29	111	66.5 %	6,775,807	0.13 %	7,794,798,739	48
2025	**10,060,418**	-0.27 %	-27,258	8,000	48.1	1.29	110	68.8 %	6,926,293	0.12 %	8,184,437,460	51
2030	**9,912,679**	-0.30 %	-29,548	10,000	49.8	1.29	108	71.1 %	7,048,858	0.12 %	8,548,487,400	52
2035	**9,747,506**	-0.34 %	-33,035	10,000	51.0	1.29	106	73.2 %	7,135,335	0.11 %	8,887,524,213	51
2040	**9,558,265**	-0.39 %	-37,848	10,000	51.6	1.29	104	75.1 %	7,178,825	0.10 %	9,198,847,240	51
2045	**9,338,123**	-0.46 %	-44,028	10,000	51.9	1.29	102	76.9 %	7,179,085	0.10 %	9,481,803,274	52
2050	**9,084,576**	-0.55 %	-50,709	10,000	52.2	1.29	99	78.5 %	7,133,527	0.09 %	9,735,033,990	54

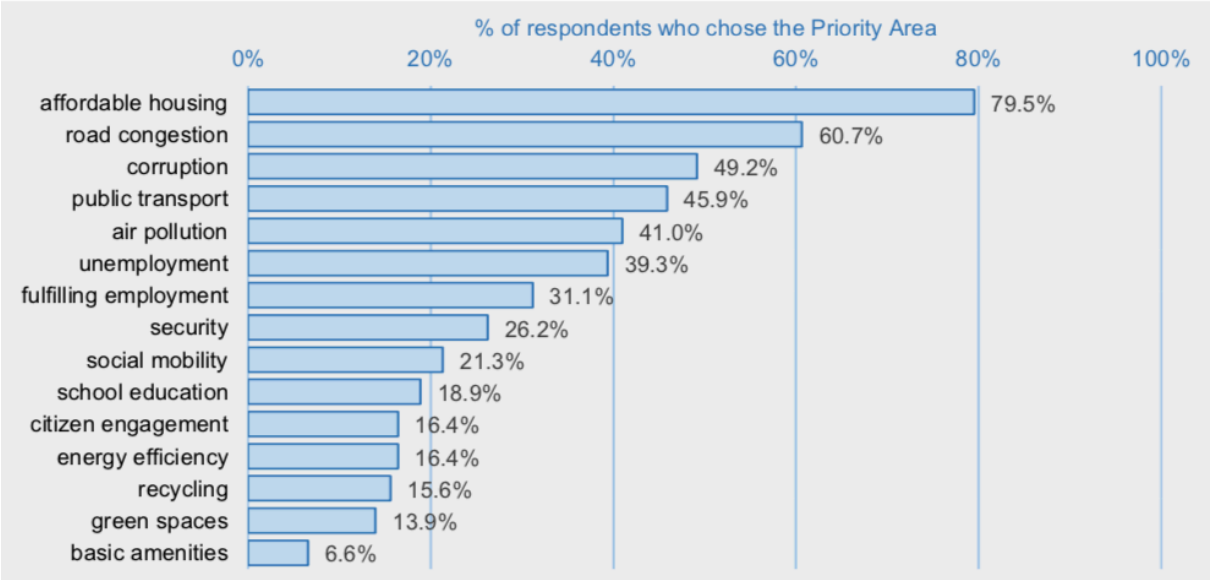
Source: Statista (2019)

Appendix 5 – Dimensions of a Smart City



Source: A behavioral framework for personality and roles (Mustafa and Kumar, 2017)

Appendix 6 – Priority Areas in Lisbon, identified by citizens



Source: Smart City Index 2019

4. IN-DEPTH SEMI-STRUCTURED INTERVIEWS

The target group of these interviews was professional people in the Smart Cities area since they could provide valuable insights based on their experience on the field. Thus, three people were interviewed in two different moments: on 15th October and on 17th October. Although some questions are the same ones for both interviews, their guides have been tailored for the specific areas of study of each one of the interviewed, so that more accurate information could be obtained.

4.1. Warm-Up

Before starting, interviewed people were contextualized with the following briefing:

"Good Afternoon! My name is Rita Brígido and, as a student of Nova SBE, I am writing my master's thesis about Smart Cities and the importance of IoT for its development, applied to Lisbon. This interview will take around one hour and it will be based on the interview guide I have shared with you before. With your authorization, I would like to record this interview with the purpose of analyzing it, more detailed, later. All your answers are completely confidential and used only for academic purposes."

4.2. Experts' Presentation

The list presented below shows a brief presentation of the experts who participated in the interviews:

First Interview (15th October 2019)

a) João Tremoceiro - Lisbon Urban Management and Intelligence Center Director – responsible at the Lisbon City Council for the coordination of the Smart Cities area, Open Data, Lisbon Urban Data Laboratory and the implementation of the Lisbon Integrated Operational Center.

Second Interview (17th October 2019)

b) Vasco Móra – Advisor of Lisbon's Mobility Deputy Mayor – mostly focused on the process analysis and management and technological opportunities and development for urban mobility;

c) David Cunha – Lisbon's Senior Adviser for Technology, Data and Urban Intelligence, and Lisbon's City Lead (H2020 Sharing Cities) – with over a decade of experience in public local administration, combined with a keen innate interest in everything technological, all blended to make an unconditional Smart(er) Cities enthusiast and Urban Intelligence supporter.

4.3. First Interview Guide

1. From your point of view, what is a Smart City or what are the required characteristics for a city having such designation?
2. According to your definition, how smart is Lisbon and how it is evolving?
3. How important is the transformation of Lisbon for becoming a Smart City?
4. What are the main barriers for the development of Smart Cities?
5. Is there any plan for the transformation of Lisbon?
6. What is the role of startups in this process? (Smart-Up)
7. How to create partnerships? Which partnerships could be important for Lisbon?
8. What are, in your opinion, the negative consequences, that could come from the creation of smart cities and the utilization of IoT for its development?
9. What is your opinion about the destruction of working stations?
10. What is the role of government in the development of Smart Cities? And what about the citizens?
11. What is the future of a human being in a Smart City?

4.4. Second Interview Guide

1. From your point of view, what is a smart city or what are the required characteristics for a city having such designation?
2. How do you characterize the concept of Smart Mobility?
3. What are the main initiatives implemented and what is its impact?
4. Have some of the projects failed? If yes, what were the main reasons?
5. Do you consider existing a big disparity in terms of mobility between the different cities of Portugal, namely between Lisbon and Porto? What are the main consequences of that?
6. What is the role of start-ups in this process? (Smart-Up)
7. How to create partnerships? What are the partnerships that could be important for Lisbon?
8. What are the next steps, in the mobility area, to transform Lisbon into a smarter city?
9. What are the main challenges? How to overcome them?
10. Technology is necessary to transform a city but also the availability of citizens. Do you think the citizens are available to participate in this development, in the mobility area?
11. What the introduction of 5G will mean for Smart Mobility?
12. What is the future of a human being in a smart city?

5. QUESTIONNAIRE SURVEY

The following questionnaire was run online to 74 people between 28th to 31st October 2019, using the Google Form tool to gather the answers (https://docs.google.com/forms/d/1c1LrlgK9rU6ecqs6pGCI5JNynXAbfWvi-vwPlvrNjJI/edit#responses).

5.1. Structure of the Survey

5.1.1. Contextual Background and Information

Before starting, interviewed people were contextualized with the following briefing:

"*Dear Participant,*

This survey takes part of my master's thesis whose theme is "The Emergence of Smart Cities and the contribution of IoT for its development". Its objective is to understand which problems are recognized by their citizens, the level of knowledge about Smart Cities, as well as the aspects that they most value to improve their quality of life.

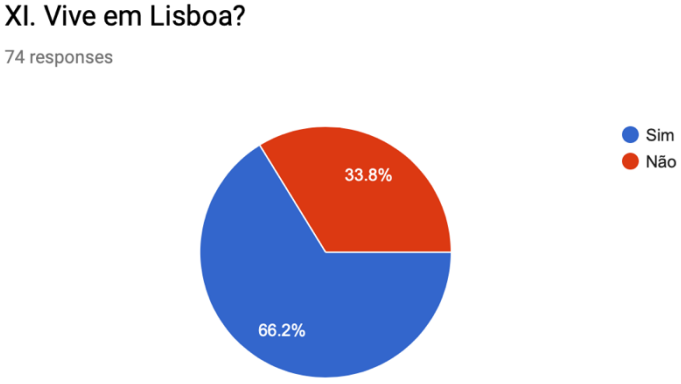
All your answers are completely confidential and used only for academic purposes.

Thank you very much in advance for your collaboration!"

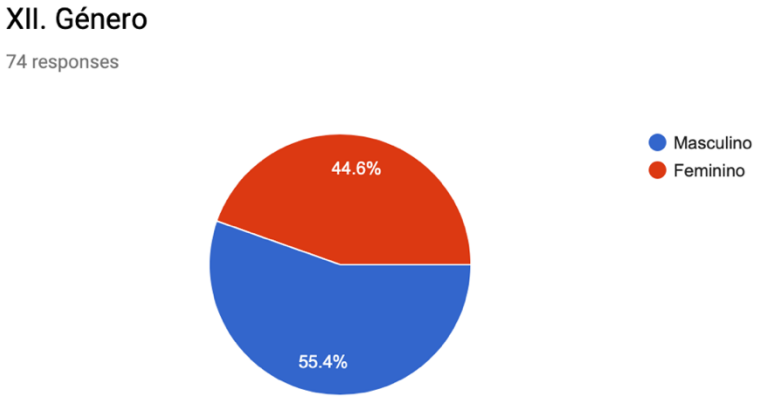
5.1.2. Respondents' Profile

Several demographics questions were asked:

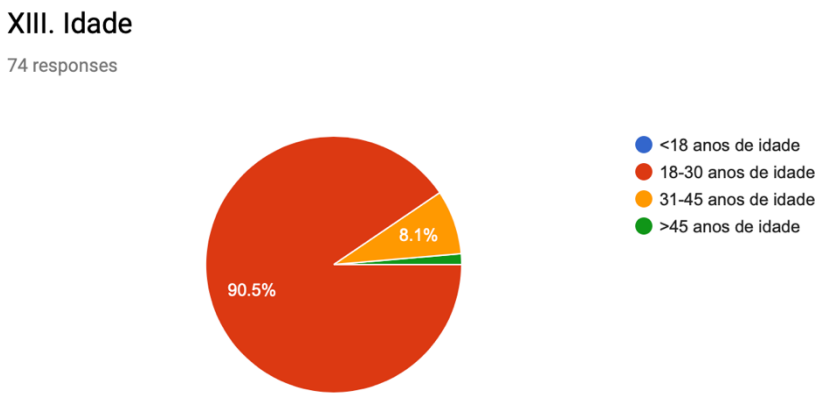
- *Do you live in Lisbon?* (Sim = Yes, Não = No)



- *What is your gender?* (Masculino = Male; Feminino = Female)

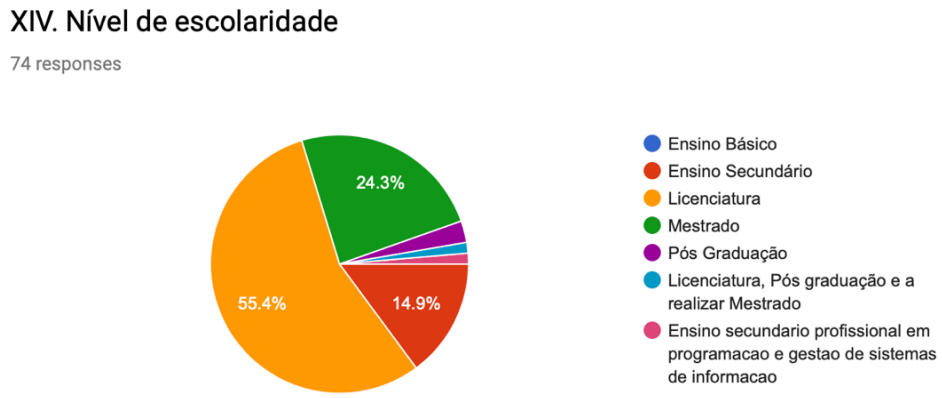


- *How old are you?*



- *What is your education level?*

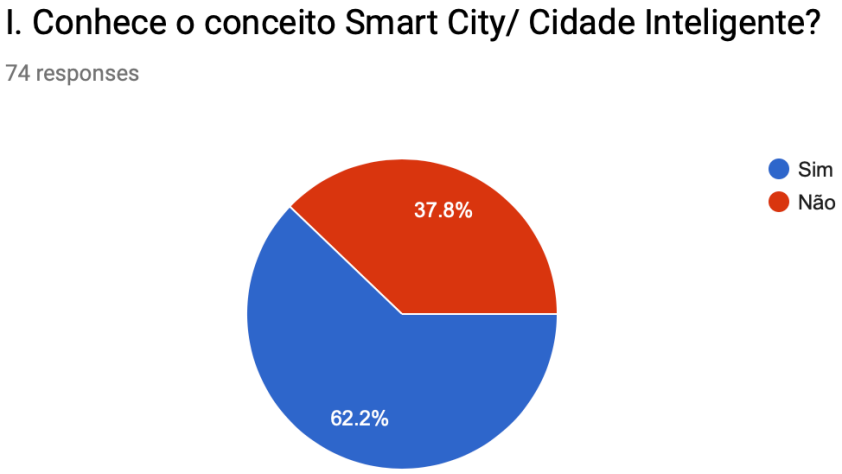
(Primary School; High School; Bachelor; Master; PhD; Bachelor, PhD and taking the Master; Technical Education)



5.2. Survey's Results

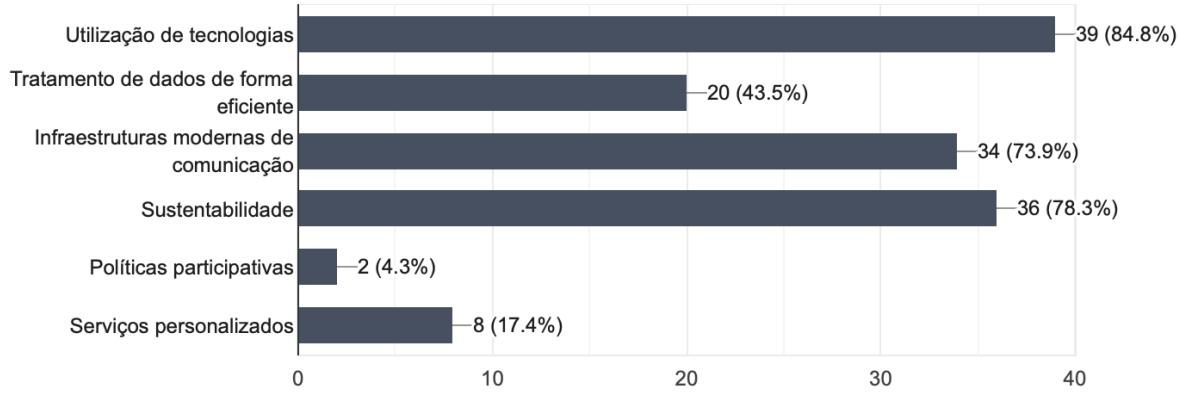
5.2.1. Awareness of the Smart City concept: "*Do you know the Smart City concept*?"

(Sim = Yes, Não = No)



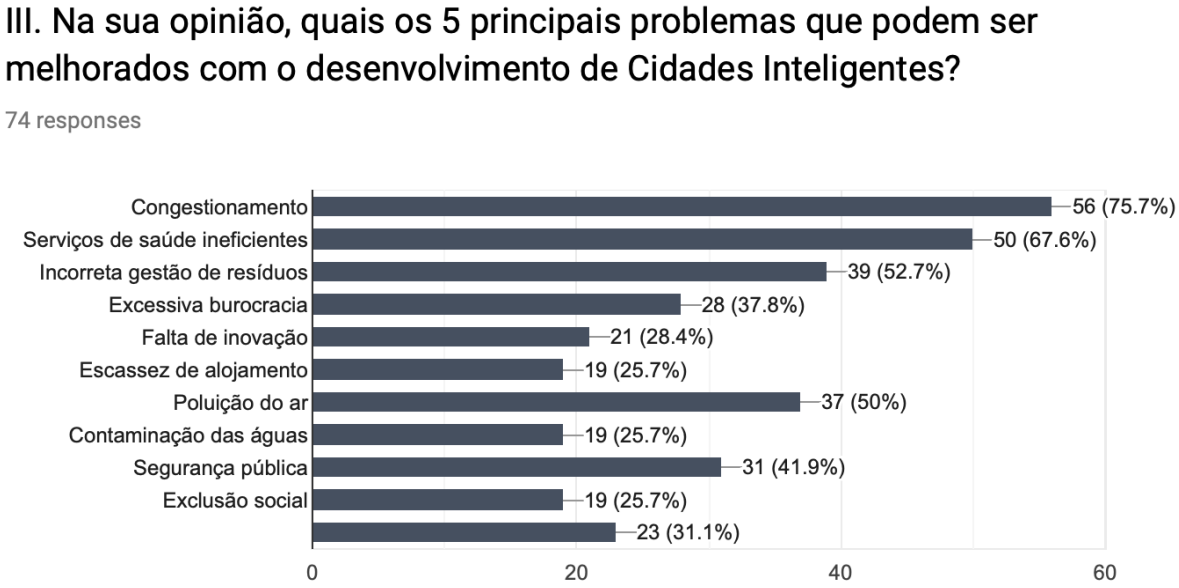
5.2.1.1. The most important characteristics: "In your perspective, which are the three most important characteristics in a Smart City?"

(Utilization of technologies, Treatment of data in an efficient way, ICT, Sustainability, Participative Politics, Personalized Services)



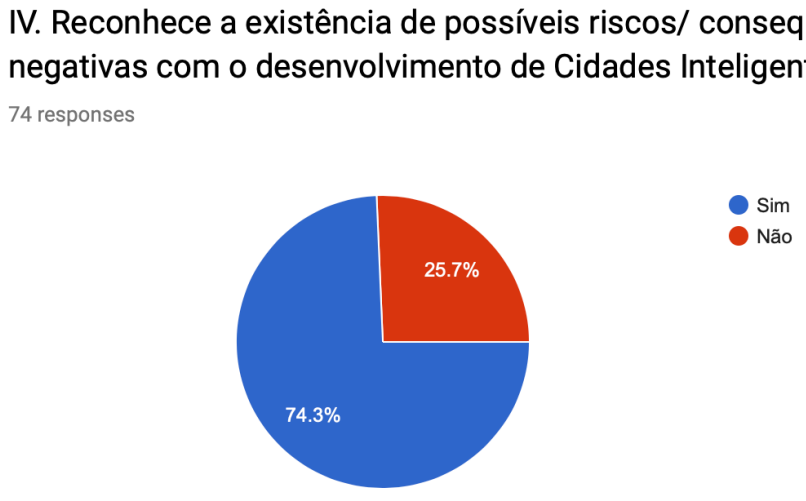
5.2.2. The main problems that would be solved with the development of Smart Cities: "In your opinion, which are the five main problems that would be improved with the development of Smart Cities?"

(Traffic, Inefficient health services, Incorrect waste management, Lack of innovation, Lack of accommodation, Air pollution, Water contamination, Public safety, Social exclusion)



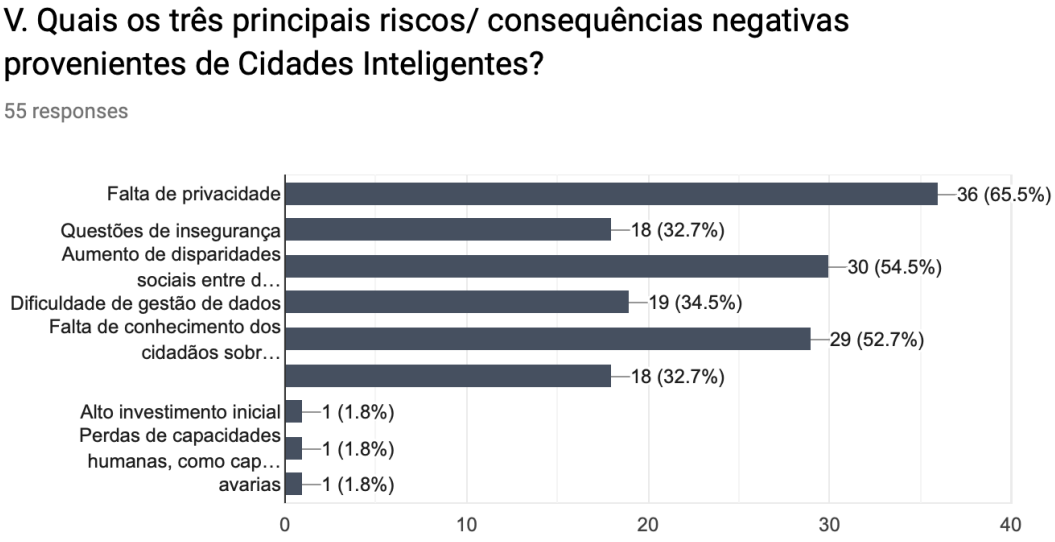
5.2.3. Possible risks and negative consequences recognition with the Smart Cities' development: "Do you recognize the existence of possible risks or negative consequences with the Smart Cities' development?"

(Sim = Yes, Não = No)

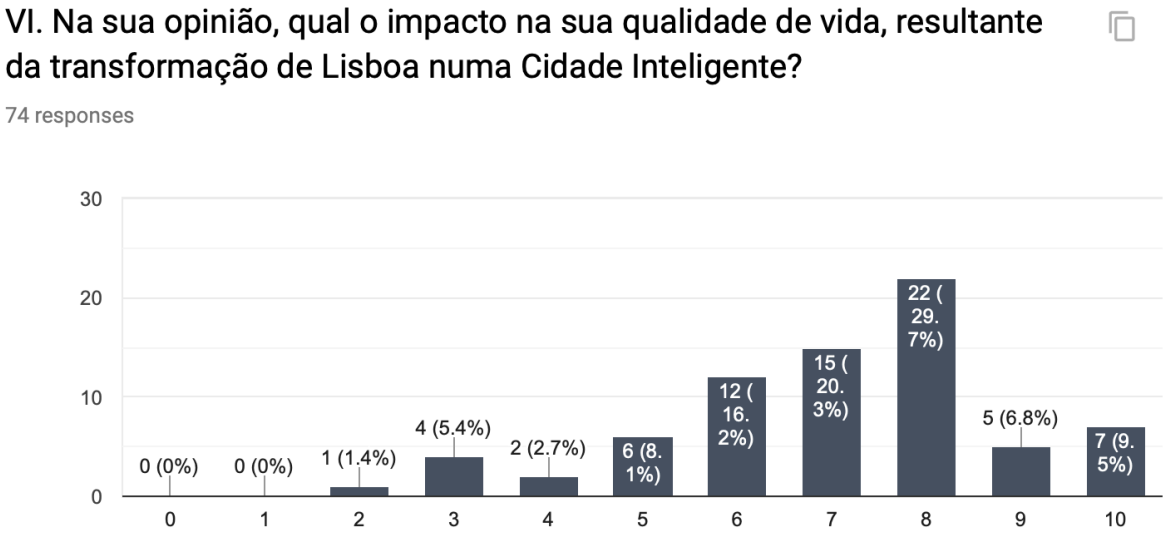


5.2.3.1. The three main risks/negative consequences: "*Which are the three main risk/ negative consequences that may come from Smart Cities?*"

(Privacy issues, Insecurity questions, Increasing social disparities between different cities in the same country, Lack of knowledge regarding this theme, High level of initial investment)

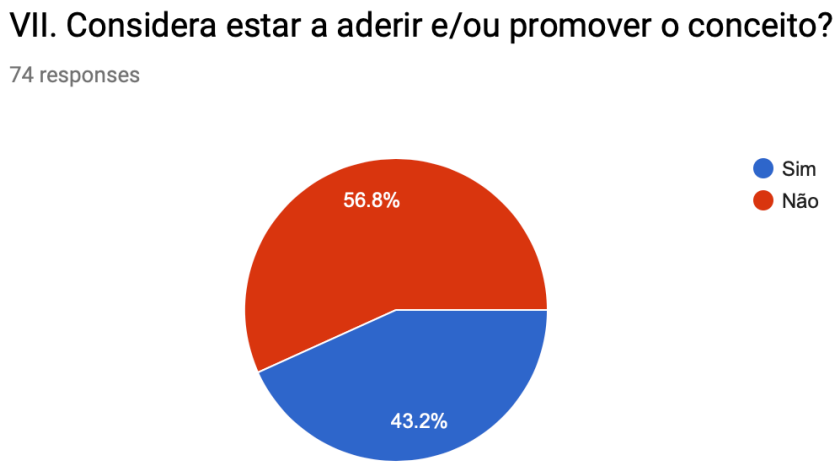


5.2.4. Impact on the quality of life: "In your opinion, what is the impact on the quality of life resulting from the transformation of Lisbon into a Smart City?"



5.2.5. Concept's promotion/ adhesion: "Are you promoting the concept?"

(Sim= Yes, Não = No)



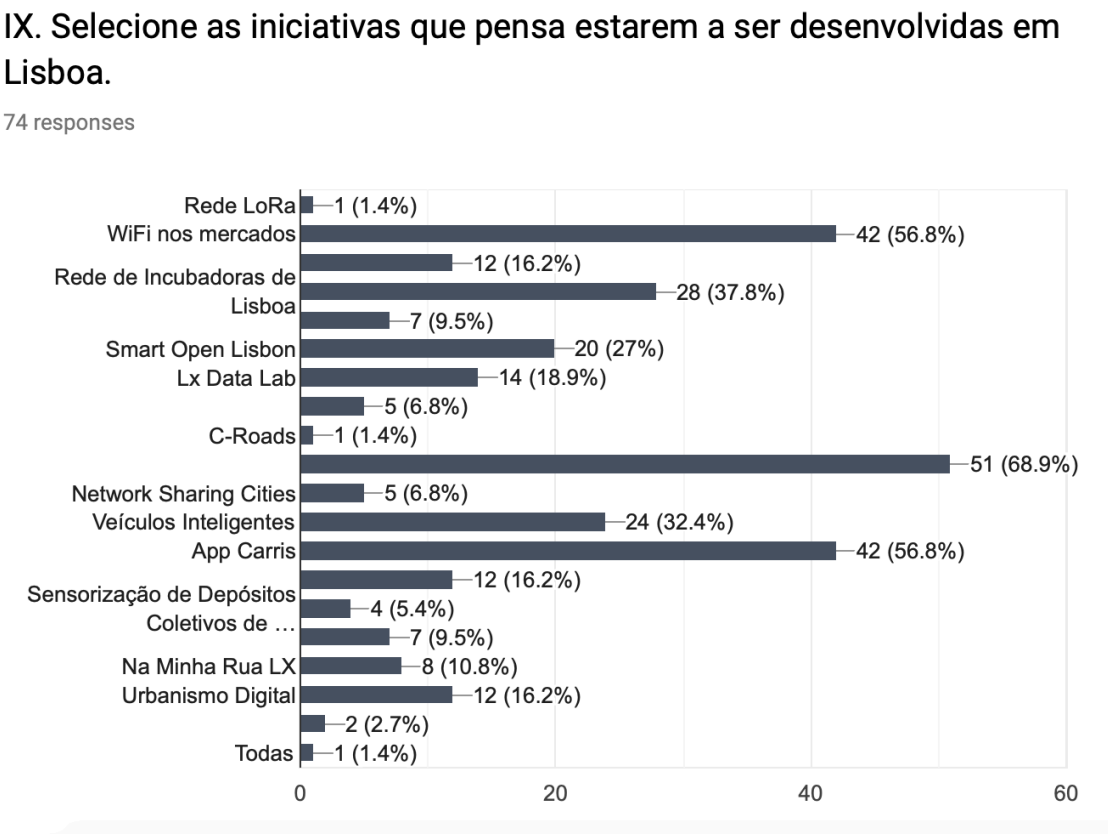
5.2.5.1. Initiatives to promote the concept: "What are you doing to promote the concept?"

- *Nothing*
- *Showing to people the main advantages*
- *Helping in the 5G development*
- *Using objects where the intelligence is implemented*
- *Supporting the main innovations*
- *Promoting the sustainability*
- *Nothing, but I will support it*
- *Online invoices, less printed paper*
- *At the moment, nothing*
- *Recycling*
- *Car sharing, traffic info sharing, waze*
- *Discussing the theme*
- *Supporting sustainable cities/ researching about it*
- *Using apps and other innovations to facilitate some processes*
- *Taking advantage of free Wi-Fi*

- *Trying to give my contribution through participative politics that may promote sustainability, improvement of quality of life and civic utilization (e.g. treadmills with floor warning lights, which allow accident prevention); helping in 5G development*
- *Trying to walk more and choose public transportation instead of using the car*

5.2.6. Perception of the initiatives that are being developed in Lisbon: "*Select the initiatives you think are being developed in Lisbon*"

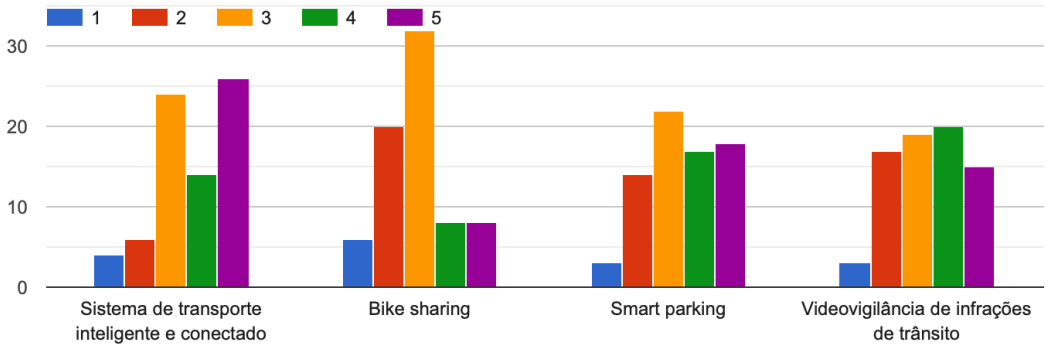
(LoRa networking, WiFi in the markets, Incubator networking, Smart Open Lisbon, Lx Data Lab, C-Roads, Networking sharing cities, Smart Vehicles, App Carris, Sensing collective waste deposits, In my street Lx, Digital urbanism)



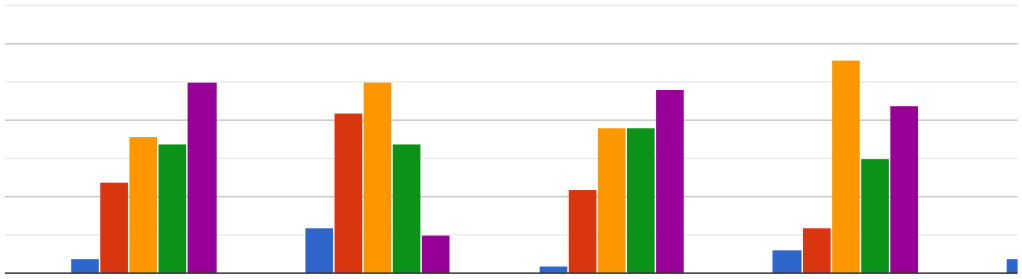
5.2.7. Ranking the applications, according to their level of importance: “Classify each one of the applications according to their level of importance”

(Smart and connected system of transportation, Bike sharing, Smart parking, Video surveillance of infringements, Smart lighting, Smart meters, Smart collective waste deposits, Air/ water smart monitoring, Civic local integration, Telemedicine, Smart Schools, Autonomous vehicles)

X. Classifique cada uma das seguintes aplicações de acordo com a sua importância.



X. Classifique cada uma das seguintes aplicações de acordo com a sua importância.



X. Classifique cada uma das seguintes aplicações de acordo com a sua importância.